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(71) Applicant(s)
Cullum Detuners Limited
(Incorporated in the United Kingdom)
Adams Close, Heanor, Derbyshire, DE75 7SW, United Kingdom

(72) Inventor(s)
Gary Turner

(74) Agent and/or Address for Service
A A Thornton & Co
235 High Holborn, LONDON, WC1V 7LE, United Kingdom

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F1B BFA BF100

(56) Documents Cited
US 5377534 A US 4122912 A

(58) Field of Search
UK CL (Edition R) B7G G7C, F1B BFA
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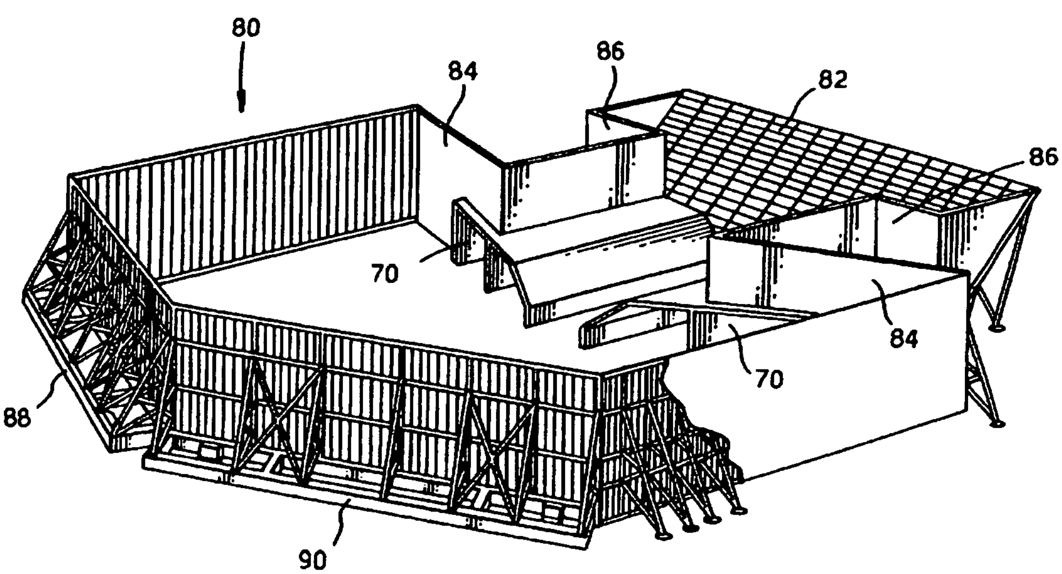
online: EPODOC, JAPIO, WPI

(54) Abstract Title
Engine test facility, eg for ground testing of aircraft gas turbine engines

(57) The engine test facility, eg run-up pen 80, has a primary noise barrier eg in the form of ramped rear wall 82 and an open ended exhaust efflux waveguide tube 70 for each engine which directs engine exhaust gases from the engine on to the rear wall 82. Thus, on release to the environment, much of the sound energy generated by each engine is transmitted to a location very close to the foot of the rear wall 82, increasing the ability of the wall to limit noise pollution. Reverse flow circulation of exhaust gases may be further reduced by collar members 84, 86 which may be lined with acoustic material. The run-up pen 80 may be provided with doors 88, 90 so that the test area is completely surrounded. A conventional run-up pen may be modified (figs. 6, 7) to comply with the invention.

Fig.8.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date but within the period prescribed by Rule 25(1) of the Patents Rules 1995.

Fig.1.

(PRIOR ART)

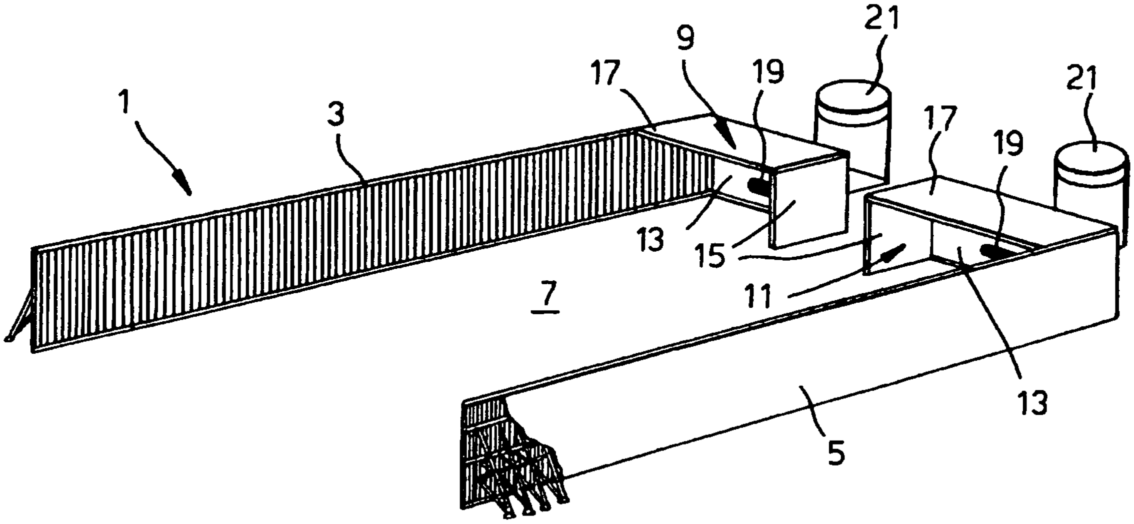

Fig.2.

(PRIOR ART)

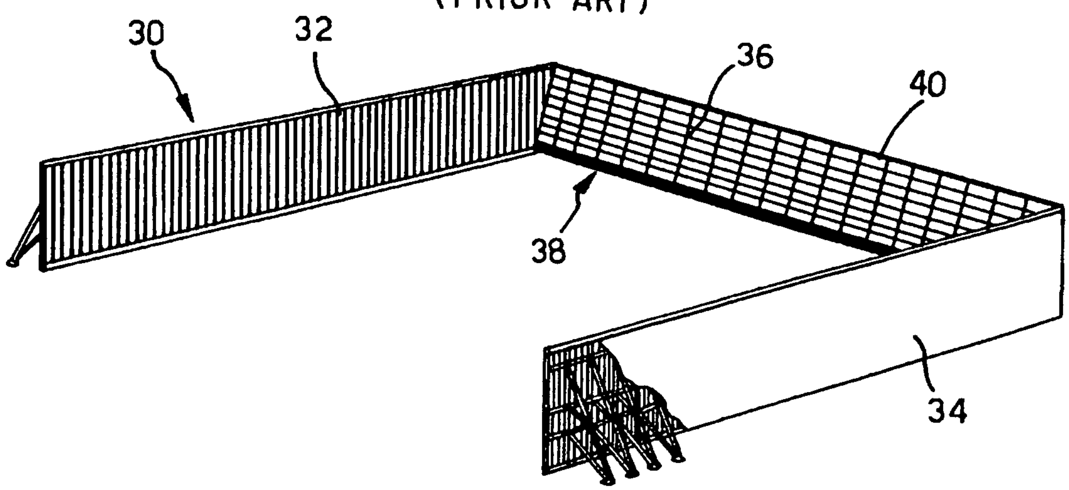

Fig.3.

(PRIOR ART)

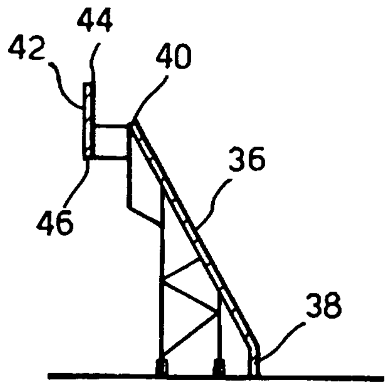

Fig.4.

(PRIOR ART)

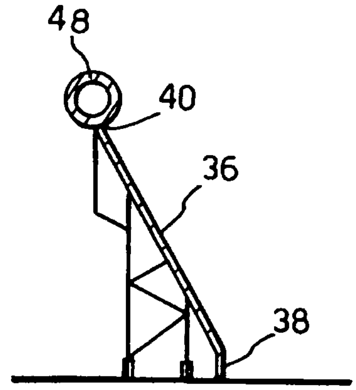

Fig.5.

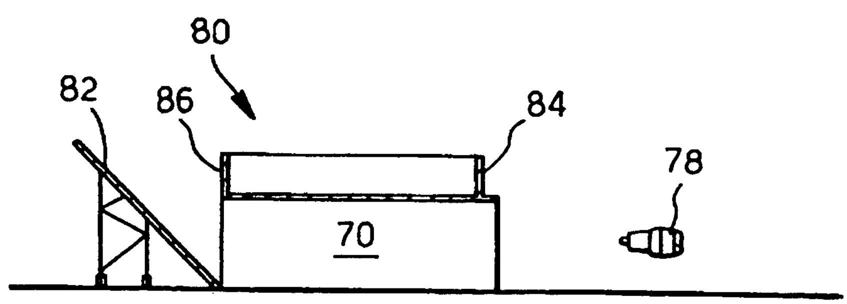

Fig.6.

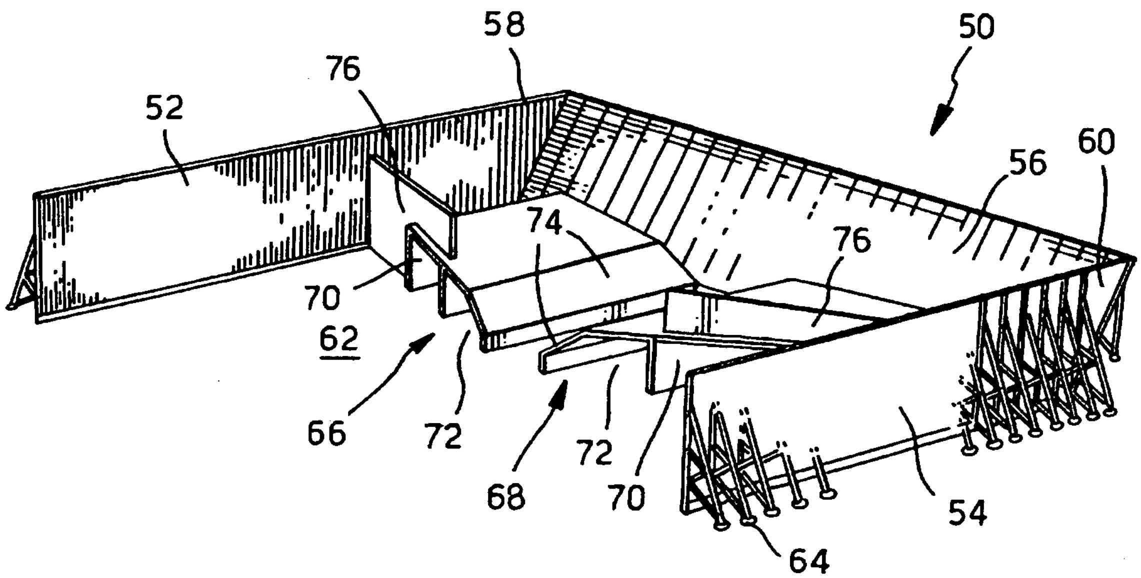
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Fig.7.

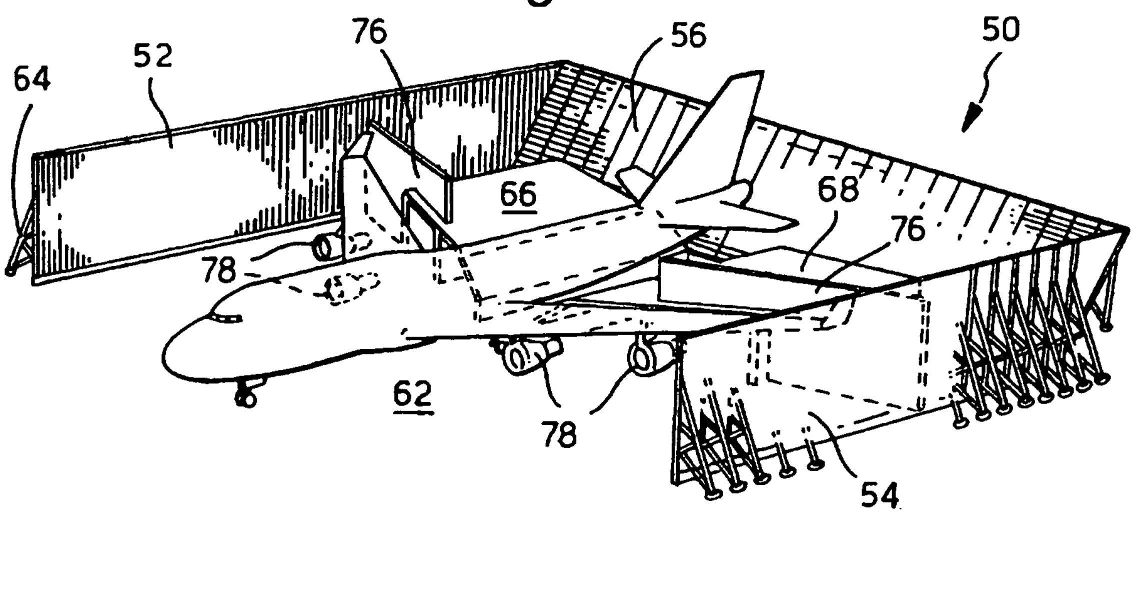
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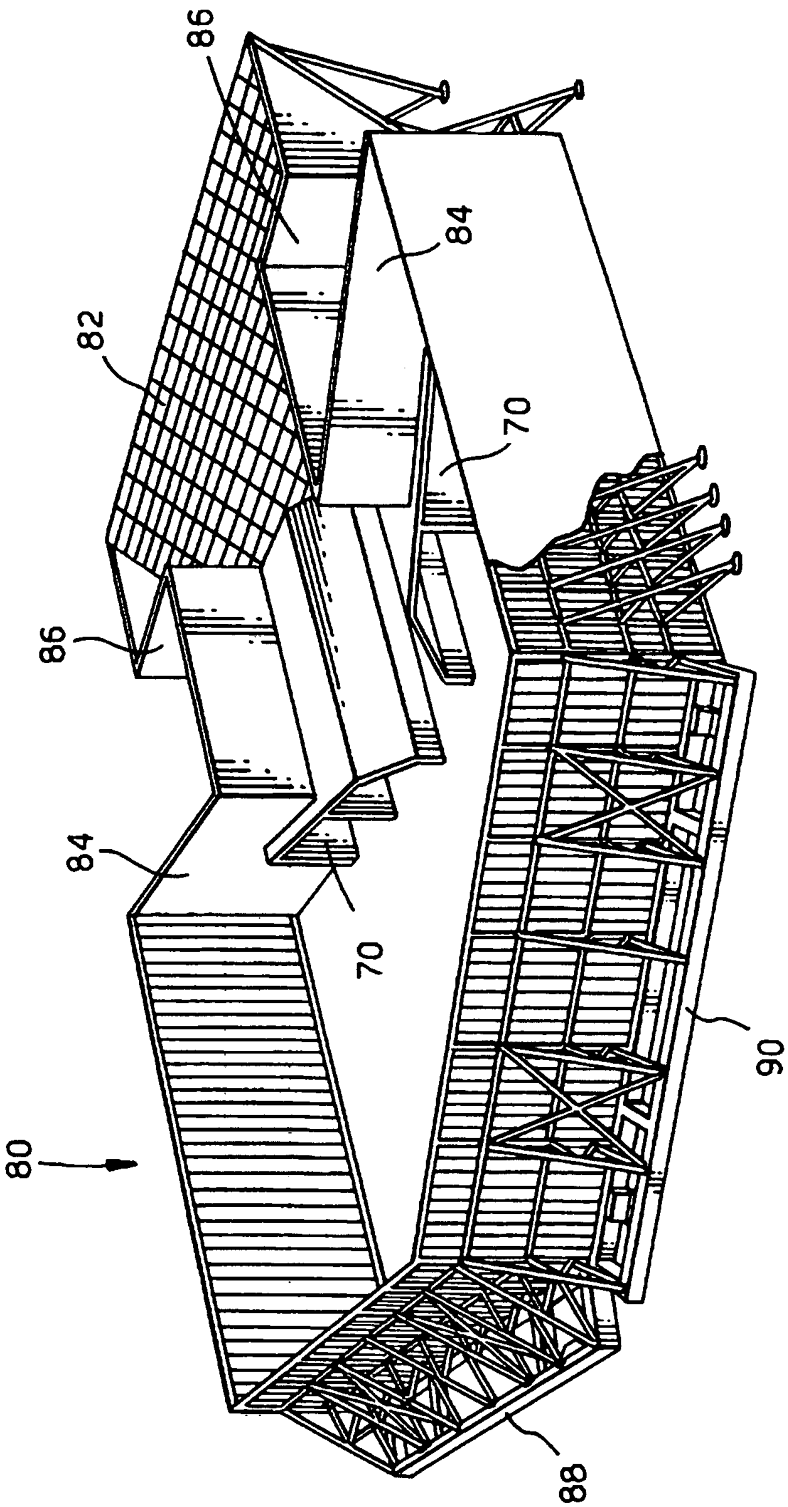
Fig.8.



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AN ENGINE TEST FACILITY

The present invention relates to facilities for testing engines, particularly, but not exclusively, to facilities for testing gas turbine engines installed on commercial aircraft.

The gas turbine engines on commercial aircraft are typically tested in facilities known as ground run-up pens. The principal function of these pens is to ensure that noise levels in surrounding areas are maintained at an acceptable level during an engine run. A further function of a run-up pen is to enhance safety by limiting access to an aircraft under test, particularly the rear of such an aircraft where exhaust gases having high temperatures and velocities are likely to be found. In this regard, a run-up pen is generally provided with means for deflecting jet blast from the area immediately to the rear of an aircraft under test. By way of illustration, two prior art run-up pens for use with commercial aircraft are shown in Figures 1 and 2 of the accompanying drawings.

A schematic view of a run-up pen (1) specifically designed to receive Concorde is shown in Figure 1. The run-up pen (1) has two opposing side walls (3,5) defining a space (7) therebetween for accommodating a Concorde aircraft. The rear of the run-up pen (1) is provided with two bays (9,11) which, during engine testing, receive exhaust gases ejected from starboard and port engines respectively. Each of the bays (9,11) is defined by a rear wall (13), a side wall (15)

and a roof element (17). The rear wall (13) of each bay (9,11) is provided with an aperture arrangement (19) and has an exhaust gas deflector tube (21) mounted on a rearwardly facing exterior surface thereof. Although the two bays (9,11) each comprise a roof element (17), the run-up pen (1) as a whole does not incorporate a roof. In this way, construction expenses are reduced and ventilation through the test facility is enhanced. The front of the enclosure incorporates two sliding doors (not shown) which, when closed, fit closely around the fuselage of the aircraft. This feature controls forward noise generated within the pen.

In use, a Concorde aircraft is pushed tail first into the run-up pen (1) and positioned so that the trailing edge of its delta wing is located adjacent the bays (9,11). The fin and rear fuselage of the Concorde aircraft is received between the side walls (15) of the two bays (9,11). During an engine test, exhaust gases are received by the aperture arrangement (19) and safely directed through the deflector tubes (21) to the atmosphere. Due to the delta shape of a Concorde wing and the trailing edge engine position employed in the Concorde design, the partially enclosed space defined by the bays (9,11) is located in very close proximity to the aircraft engines during testing. Thus, much of the sound energy emitted from the engines, particularly that associated with the exhaust gas, is surrounded and significantly dampened by the bays (9,11) before being released into the environment.

Although the run-up pen (1) shown in Figure 1 provides reasonable acoustic performance, the facility can only be used to ground test one specific aircraft. Aircraft other than Concorde cannot be used in the run-up pen (1). In order to provide a more flexible facility, the run-up pen (30) shown in Figure 2 has been developed. This run-up pen (30) comprises two opposing side walls (32,34) sufficiently spaced to allow the reception therebetween of large commercial aircraft such as the Boeing 747-400. The run-up pen (30) shown in Figure 2 is therefore considerably larger than the run-up pen (1) shown in Figure 1 which is designed to accommodate the comparatively small Concorde aircraft. Although the physical reception of large aircraft within a run-pen is readily achievable,

adaption of the relatively effective bays (9,11) of the Concorde run-up pen (1) to a flexible multi-aircraft facility is not possible. Accordingly, an alternative means in the form of a ramped deflector wall (36) has been employed for reducing sound pollution and minimising the dangers associated with turbine exhaust gas.

The deflector wall (36) is located at the rear of the run-up pen (30) and extends from one of the side walls (32,34) to the other thereof. The foot (38) of the deflector wall (36) is arranged vertically, however the remainder (and vast majority) of the deflector wall (36) is ramped so as to define an angle of approximately 30° with the vertical.

Since the deflector wall (36) spans the entire width of the run-up pen (30) shown in Figure 2, any engine position across the width of the pen (30) will be accommodated. Thus, aircraft of different sizes and having different numbers of engines may be safely tested in the run-up pen (30) with the deflector wall (36) performing as both a jet blast deflector and an acoustic barrier. Again primarily due to cost and ventilation considerations, a roof is not incorporated into the design of the run-up pen (30).

Although the run-up pen (30) shown in Figure 2 is capable of accommodating numerous types of commercial aircraft, the acoustic performance of the facility is rather poor and, in many cases, fails to reduce noise pollution to currently accepted levels. The flexibility of the run-up pen (30) is mainly attributable to the use of a single deflector wall (36) spanning the entire distance between the side walls (32,34). Thus, in order to retain flexibility whilst improving acoustic performance, modified pen designs have been developed wherein a deflector wall (36) is provided with an upper or diffracting edge (40) incorporating an acoustic feature. Two such features can be seen from the cross-sectional views of modified deflector walls shown in Figures 3 and 4 of the accompanying drawings. The arrangement shown in Figure 3 incorporates a baffle plate (42) mounted adjacent the diffracting edge (40). The baffle plate (42) provides two further diffracting edges (44,46) which further reduce noise levels. The alternative arrangement shown in Figure 4 also reduces noise levels through the provision of

an acoustically absorbent cylinder (48) located on the diffracting edge (40) of the deflector wall (36). When applied to the run-up pen (30) of Figure 2, both the modifications shown in Figures 3 and 4 improve the screening effect by an estimated 2dB(A). Although clearly beneficial, reductions of this magnitude do not improve acoustic performance sufficiently for current requirements to be satisfied. Furthermore, although a baffle plate (42) or an acoustically absorbent cylinder (48) may be conveniently provided on a new deflector wall design, the technical difficulties associated with adding loads to the diffracting edge (40) of existing structures tends to render the modifications shown in Figures 3 and 4 impractical and not cost effective.

A further option of increasing the height of the side walls (32,34) and deflector wall (36) of a run-up pen is also not viable due to the ineffectiveness of increasing barrier height and flight path requirements which restrict the height of buildings located on airfields to a minimum. Prior art run-up pens are generally already constructed to the maximum permitted height of 12 metres.

It is an object of the present invention to provide an engine test facility capable of accommodating all current commercial aircraft and all known future commercial aircraft.

It is also an object of the present invention to provide an engine test facility which improves noise reduction over the prior art by a minimum of between 3dB(A) and 5dB(A).

It is a further object of the present invention to provide an engine test facility which may be adapted to receive a range of aircraft in a rapid, convenient and inexpensive manner.

Furthermore, it is an object of the present invention to provide an engine test facility capable of being rapidly and inexpensively constructed.

The present invention provides an engine test facility comprising means for reducing sound energy passing from a first location inside said facility to a second location outside said facility, wherein said means comprises a barrier for obstructing the passage of sound energy from the first location to the second

location; and an open ended tube, one open end thereof being positioned adjacent said first location and a second open end thereof being positioned at a third location, said third location being closer to the barrier than said first location and being on the opposite side of the barrier to said second location.

Thus, during use of an engine test facility according to the present invention, an aircraft gas turbine engine may be positioned at a first location inside the facility adjacent an open end of a waveguide tube. The waveguide tube extends from adjacent the aircraft engine towards an acoustic barrier serving to diffract sound energy which would otherwise be transmitted substantially unobstructed to a second location outside the facility such as a populated residential development. The waveguide tube will typically extend in the direction of travel of the exhaust gas emitted from the aircraft engine and open at a third location adjacent the foot of the acoustic barrier. Accordingly, much of the sound energy generated by the aircraft engine (particularly that associated with the exhaust gas) will, rather than radiating immediately from the engine to the environment, be received within the waveguide tube (together with the exhaust gas itself) and be directed towards the acoustic barrier. Although some sound energy will radiate from the walls of the waveguide tube, much of the sound energy received by the waveguide tube will be directed along the tube length and not released to the environment until progression has been made to the end of the waveguide tube distal to the aircraft engine.

The waveguide tube therefore acts to move the point at which sound energy is released to the environment from the location of the sound energy's original source (i.e. the aircraft engine) to a location very close to the acoustic barrier. In so moving the point of release of sound energy, the effectiveness of the acoustic barrier in diffracting the released sound energy is significantly increased. One or more tubes may be conveniently arranged so as to accommodate a multiplicity of engine positions corresponding to various types of commercial aircraft.

Preferably, the facility comprises a plurality of said means for

reducing a passage of sound energy, the plurality of said means comprising a common barrier. It is further preferable for the facility to comprise four of said means for reducing a passage of sound energy. The or each tube of said means may be partially defined by a floor surface of the engine test facility. Walls of the or each tube may also be provided with an acoustic material for reducing the passage of sound energy therethrough. The acoustic material is ideally a mineral based fibre noise absorbing material protected by perforated steel sheet.

Furthermore, the or each barrier for obstructing the passage of sound energy is arranged so as to deflect substantially vertically upwards sound energy emanating from an associated tube. The or each tube is preferably arranged substantially horizontally and the or each barrier is preferably arranged as a flat wall raked at a substantially 45° angle to the vertical. The or each barrier is ideally a jet blast deflector.

It is further preferable for a second acoustic barrier to extend outwardly from an outer surface of at least one of the or each tubes. The or each second acoustic barrier preferably extends in a generally lateral direction to a side wall of the facility. It is desirable for the engine test facility to comprise side walls having projections defined thereon for restricting fluid flow thereon.

Thus, an engine test facility according to the present invention has several advantages over the prior art. Firstly, the invention provides means for modifying prior art run-up pens so as to reduce the residual noise levels associated with such pens by at least 3dB(A). The present invention also provides a run-up pen having not only acceptable acoustic performance but also the capability of accommodating any size of a commercial aircraft. The tubes of the present invention also improve safety of an engine test facility by shrouding dangerous exhaust gas. Secondary acoustic barriers and projections defined on side walls also reduce the risk of hot gas and vortex reinjestion. Also, the raking of the primary acoustic barrier at a 45° angle to the vertical ensures that sound energy and exhaust gas tends to be deflected vertically upwardly. These features combine to reduce the risk of catastrophic engine surge and allow testing of an engine across a larger

proportion of its operating range. Furthermore, the present invention provides a facility which may be manufactured in a relatively rapid and inexpensive manner.

Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of a first prior art run-up pen;

Figure 2 is a schematic perspective view of a second prior art run-up pen;

Figure 3 is a schematic cross-sectional side view of a prior art deflector wall provided with a baffle plate;

Figure 4 is a schematic cross-sectional side view of a prior art deflector wall provided with an acoustically absorbent cylinder;

Figure 5 is a schematic cross-sectional side view of an embodiment of the present invention;

Figure 6 is a schematic perspective view of a further embodiment of the present invention;

Figure 7 is a schematic perspective view of the embodiment of Figure 6 accommodating a large commercial aircraft; and

Figure 8 is a schematic perspective view of the embodiment of Figure 5.

A first ground run-up pen 50 according to the present invention is shown in Figures 6 and 7 of the accompanying drawings. The first run-up pen 50 has a basic structure identical to that of the second prior art run-up pen (30) shown in Figure 2. Accordingly, the first run-up pen 50 incorporates two parallel opposing side walls 52,54 with a ramped rear wall 56 extending between end portions 58,60 thereof. The side walls 52,54 and the ramped rear walls 56 are located on three sides of a square and thereby define a testing area 62 sufficiently large to accommodate all current and known future commercial aircraft. The ramped rear wall 56 is raked at an angle of 30° to the vertical and functions as both a jet blast deflector and an acoustic barrier. The base or foot portion (not shown)

of the ramped rear wall 56 has a vertical inner facing surface. The outer facing surfaces of the side walls 52,54 and the ramped rear wall 56 are mounted to a truss arrangement 64 which provides the run-up pen 50 with adequate structural integrity.

Further to the aforementioned basic structure which is already comprised in the prior art, the first run-up pen 50 according to the present invention has two exhaust efflux waveguide tube assemblies 66,68 located within the testing area 62 at the foot of the ramped rear wall 56. The two exhaust efflux waveguide tube assemblies 66,68 are mirror images of each other and each comprises two elongate straight tubes 70,72. The tubes 70,72 are preferably lined with a suitable acoustic material (such as a mineral based fibre noise absorbing material protected by perforated steel sheet) so as to limit the sound energy radiating through the walls thereof. The tubes 70,72 of each waveguide assembly 66,68 have a generally rectangular cross-section. Furthermore, so as to assist with the accommodation of an aircraft fuselage, each waveguide assembly 66,68 is provided with a sloping surface 74.

In addition to the two tubes 70,72, each exhaust efflux waveguide assembly 66,68 has a collar member 76 which performs as a secondary acoustic barrier. Each collar member 76 extends upwardly from the outermost tube 70 and laterally outwardly from said tube so as to abut the adjacent side wall 52,54. The collar members 76 do not extend across the centrally located tubes 72 so that sufficient clearance may be provided for the tail plane of an aircraft. Both the collar member 76 and leading edge of the tubes 70,72 of each waveguide assembly 66,68 are raked in plan so as to broadly correspond to the trailing edge raking typically found on a commercial aircraft wing.

A view is shown in Figure 7 of a Boeing 747-400 located within the testing area 62 of the first run-up pen 50. It will be seen that the four engines 78 of this aircraft are generally located immediately in front of a tube 70,72 of one of the waveguide assemblies 66,68. Thus, during engine testing, exhaust gases from each engine 78 are directed through one of the tubes 70,72 and on to the ramped rear

wall 56. Sound energy emanating from an engine 78 (particular that associated with the exhaust gases) is also received within a tube 70,72 and directed to the ramped rear wall 56. The acoustic lining of each tube 70,72 limits the amount of sound energy radiating from the length of each tube 70,72. Thus, on release to the environment, much of the sound energy generated by an engine 78 has been transmitted to a location very close the foot of the ramped rear wall 56. The ability of the ramped rear wall 56 to defract the sound energy produced by an engine 78 is thereby greatly enhanced and the noise pollution released to the environment is greatly reduced.

The collar member 76 of each waveguide assembly 66,68 also acts to defract sound energy generated by an engine 78 and therefore assists in reducing noise pollution. The collar members 76 also have the effect of limiting a reverse flow of exhaust gas from the ramped rear wall 56 along the side walls 52,54. Accordingly, outboard engines 78 located adjacent the side walls 50,54 are less likely to ingest hot gases and vortices. This can reduce the likelihood of surging and allow testing of an engine 78 over a larger proportion of its operating range.

Furthermore, vortices generated by adverse wind conditions (i.e. wind blowing onto the reverse side of the ramped rear wall 56 rather than directly into the testing area 62 from the open end of the run-up pen 50) are deflected from the engines 78 by the collar members 76. The run-up pen 50 therefore allows testing in an extended range of weather conditions vis-à-vis the prior art.

It will be seen that the tubes 70,72 of the waveguide assemblies 66,68 span a sufficient width of the testing area 62 to allow the testing of aircraft differing in size and configuration to the Boeing 747-400.

The embodiment shown in Figures 6 and 7 is of an existing run-up pen modified so as to comply with the present invention and thereby benefit from the advantageous characteristics thereof. However, a purpose built "from new" ground run-up pen 80 according to the present invention is shown in Figures 5 and 8 of the accompanying drawings. The second run-up pen 80 is similar to the first run-up pen 50, however there are a number of variations which in many

circumstances will be regarded as desirable. Firstly, the ramped rear wall 82 is raked at an angle of approximately 45° to the vertical. Exhaust gases directed on to the rear wall 82 are thereby deflected vertically away from the testing area rather than, at least in part, back towards the test area. Deflection of jet blast is also assisted by removal of the vertical surface located at the foot of the rear wall (see Figure 5). Reverse flow circulation of exhaust gases is still further reduced by the provision of collar members 84,86 at each end of the outermost tubes 70. If appropriate, the collar members 84,86 may be provided with a suitable acoustic material. Finally, the second run-up pen 80 is provided with two doors 88,90 which may be shut to provide a completely surrounded test area.

The present invention is not limited to the specific embodiments described above. Alternative arrangements and suitable materials will be apparent to a reader skilled in the art.

CLAIMS:

1. An engine test facility comprising means for reducing sound energy passing from a first location inside said facility to a second location outside said facility, wherein said means comprises

a primary barrier for obstructing the passage of sound energy from the first location to the second location; and

an open ended tube, one open end thereof being positioned adjacent said first location and a second open end thereof being positioned at a third location, said third location being closer to the barrier than said first location and being on an opposite side of the barrier to said second location.

2. An engine test facility as claimed in claim 1, wherein said facility comprises a plurality of said means for reducing a passage of sound energy, the plurality of said means comprising a common primary barrier.

3. An engine test facility as claimed in claim 1 or 2, wherein said facility comprises four of said means for reducing a passage of sound energy.

4. An engine test facility as claimed in any preceding claim, wherein the or each tube is partially defined by a floor surface of the engine test facility.

5. An engine test facility as claimed in any preceding claim, wherein walls of the or each tube are provided with an acoustic material for reducing the passage of sound energy therethrough.

6. An engine test facility as claimed in claim 5, wherein the acoustic material is mineral based fibre noise absorbing material protected by perforated steel sheet.

7. An engine test facility as claimed in any preceding claim, wherein a secondary barrier for obstructing the passage of sound energy from the first location extends outwardly from an outer surface of the open ended tube or at least one of the plurality of open ended tubes.

8. An engine test facility as claimed in claim 7, wherein the or each secondary barrier extends in a generally lateral direction to a side wall of the facility.

9. An engine test facility as claimed in any preceding claim, wherein the or each tube is straight.

10. An engine test facility as claimed in any preceding claim, wherein the or each primary barrier for obstructing the passage of sound energy is arranged so as to deflect substantially vertically upwards sound energy emanating from an associated tube.

11. An engine test facility as claimed in claim 10, wherein the or each tube is arranged substantially horizontally and the or each primary barrier is arranged as a flat wall raked at a substantially 45° angle to the vertical.

12. An engine test facility as claimed in any preceding claim, wherein the or each primary barrier is a jet blast deflector.

13. An engine test facility as claimed in any preceding claim, wherein the facility comprises side walls having projections defined thereon for restricting fluid flow therealong.

14. An engine test facility substantially as hereinbefore described with reference to and as shown in Figures 5 to 8 of the accompanying drawings.

Application No: GB 9916204.2
Claims searched: 1 to 14

Examiner: John Twin
Date f search: 3 October 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B7G (G7C); F1B (BFA)

Int Cl (Ed.7): B64F 1/26

Other: online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US 5377534 (SA André Boet)	
X	US 4122912 (US Navy)	1,9-12 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.